Japanese Patent Laid-Open No. Sho 63-133521

Specification

1. Title of the Invention

Heat Treatment Apparatus for Semiconductor Substrate

2. What is claimed is

A heat treatment apparatus for a semiconductor substrate in which a chamber is constituted by a load lock chamber 4 having an opening/closing door 4a opened when a wafer 11 is loaded/unloaded, a heat treatment chamber 12 for subjecting the wafer 11 to a heat treatment, and a wafer transferring chamber 3 in communication with both chambers 4, 12; a gate valve 7 for opening or closing a wafer loading/unloading port for both chambers 3, 4 is provided between the load lock chamber 4 and the wafer transferring chamber 3; a wafer holder 28 for moving the wafer 11 between the chambers 3, 4 is provided on the gate valve 7; the gate valve 7 is provided with the wafer holder 28 for transferring the wafer 11 between both chambers 3, 4, a gate valve 9 for opening or closing the wafer loading/unloading port for the chambers 3, 12 is provided between the wafer transferring chamber 3 and the heat

treatment chamber 12; a wafer holder 10 for moving the wafer 11 between the chambers 3, 12 and rotating the wafer 11 is provided on the gate valve 9; a wafer transferring mechanism 5 for loading which transfers the wafer 11 received from the wafer holder 28 and delivering the same to the wafer holder 10 and a wafer transferring mechanism 6 for unloading which performs an operation opposite to that of the wafer transferring mechanism 5 are provided in the wafer transferring chamber 3; a wafer cooling portion 8 is provided for cooling the wafer 11 being transferred by the wafer transferring mechanism 6; an exhausting device 18 and a gas supplying portion 17 are connected to the load lock chamber 4, the wafer transferring chamber 3, and the heat treatment chamber 12; and an upper surface heating source 13a for the wafer 11 and a side surface heating source 13b for the wafer 11 are provided on the upper part and the side part of the heat treatment chamber 12, respectively.

3. Detailed Description of the Invention

[Field of the Invention]

This invention relates to a heat treatment apparatus for a semiconductor substrate used in a manufacturing step of a semiconductor device.

[Prior Art]

Although a heat treatment is an essential process in

a manufacturing step for a semiconductor device, the prior art heat treatment performed through an electric furnace has shown a certain limitation as the size of the element has been made fine. For example, it is possible to apply a heat treatment for use in forming a shallow connecting portion after ion implantation. It has been found that as means for overcoming this problem, a method for directly heating a wafer for a short period of time with a halogen lamp is effective. Further, the aforesaid method has been made apparent to provide some merits which could not be attained by the prior art in many applications related to the heat treatment such as forming of silicide or re-flow of an insulation film, forming of alloy, sintering of electrode wiring, and forming of a thin oxidization film or nitrization film in addition to a heat treatment after ion implantation.

Fig. 9 is a perspective view for showing a schematic configuration of a heat treatment apparatus with a rod-like halogen lamp widely used in the prior art.

In Fig. 9, reference numeral 51 denotes a loading wafer cassette for use in storing non-processed wafers. In the case of diameter of 6″ or less, the wafers are normally stored in an equal spacing with a pitch of 3/16″ (4.76mm). When transferring the wafer, the cassette 51 is lowered by a drive mechanism (not shown) by one pitch and it is

stopped when the wafer 11 at the lowest position in the cassette is contacted with the upper surface of the loading wafer transferring belt 53. After this operation, the belt 53 is rotated in the arrow direction, whereby the wafer in the cassette 51 is transferred from the storing position A to the unloading position (B).

The wafer 11 transferred to the unloading position B is mounted on an extremity end fork mounting portion of the wafer transfer arm 56 and transferred to a predetermined position C within the chamber 62 by the wafer transferring arm 56 through a wafer loading/unloading port 58 (the gate valve 57 is kept open) of the chamber 62 made of quartz and having a rectangular sectional surface.

The transferred wafer 11 is placed at the predetermined position C, and the vacant wafer transferring arm 56 is moved out of the chamber 62. After this operation, the gate valve 57 is closed and the wafer is heated by many rod-like halogen lamps 13a, 13c for the upper surface and lower surface heating sources installed at the upper and lower surfaces of the chamber 62. Reference numeral 35 denotes a reflection plate for improving a heating efficiency.

Although heating of wafer is normally performed in inert gas atmosphere including N_2 gas or Ar gas, it is desirable that impurity gas other than the specified gas

atmosphere is avoided as much as possible. Accordingly, in a case where the wafer is subjected to a heat treatment in N_2 gas atmosphere, for example, it is necessary that the gate valve 57 is opened and the wafer is loaded and unloaded while the gas is flowing from the gas inlet portion 63 to prevent air from entering the chamber 62. This is due to the fact that the wafer heated up to high temperature is quite active, and either oxygen or impurity gas contained in air reacts with the interface plane of the wafer within a short period of time, or dispersion of the impurities proceeds into the wafer.

Heating of the wafer is normally performed such that the wafer is placed in the chamber made of quartz and having a rectangular sectional surface and heated by the rod-like halogen lamps 13a, 13c placed at the upper surface and the lower surface of the chamber 62 while the inside part of the chamber 62 is kept in the specified gas atmosphere.

Heating time is about 1 to 60 seconds and heat treatment can be performed while the wafer is being held for a specified period of time at the specified temperature (for example, it is held for 5 seconds at 1000℃).

Upon completion of heat treatment, the gate valve 57 is opened, the wafer-transferring arm 56 is inserted again into the chamber 62, the wafer is mounted on the extremity

end fork mounting portion and the wafer is transferred from the predetermined position C to the unloading position B. After this operation, the processed wafer at the unloading position B is stored in the unloading wafer cassette 52 by the unloading wafer transferring belt 54.

In addition, the heated wafer is needed to be cooled, and a method is employed in which after unloading the wafer out of the chamber, the wafer is cooled at the unloading position B or a cooling portion is provided between the unloading position B and the storing position D of the cassette 52 to cool the wafer.

Subsequently, the aforesaid series of works are performed. The non-processed wafers stored in the loading wafer cassette 51 are transferred in sequence automatically, subjecting to processing in the chamber 62, and then the processed wafers are stored in the unloading wafer cassette 52.

[Problems to be Solved by the Invention]

However, the aforesaid prior art device has the following problems.

① In a case where the inside gas in the chamber 62 is replaced with inert gas, the inside area in the chamber is evacuated to cause the chamber to be broken in view of its structure, so that the inside part of the chamber 62 cannot be evacuated and a rapid and positive gas

replacement cannot be performed.

② Since the lamps 13a, 13c are provided at the upper surface and the lower surface of the chamber 62, it is difficult to cope with radiated heat released around the wafer. To be more concrete, much amount of thermal radiation is found in particular at the gas feeding portion 63 and the wafer loading/unloading port 58, the wafer surface shows much dispersion in temperature distribution, and a slip line may easily be produced.

③ Although rotating the wafer is a superior means to improve a temperature distribution in a circumferential direction of the wafer, the lamps 13a, 13c are provided at both upper and lower surfaces of the chamber 62. Therefore it is quite difficult to use a wafer rotating means.

④ Although it is desirable to cool the wafer down to a certain specified temperature (for example, about 200℃) within the specified atmosphere, the cooling portion is provided outside the chamber 62 in the prior art device, which means that the wafer is cooled in the air, and even if the wafer processing is performed in the gas atmosphere of specified high purity, oxidation and dispersion at the wafer surface are promoted at the cooling stage. Therefore this means that a superior heat treatment was not performed.

In order to avoid the above-mentioned problem, although it may also be applicable that the cooling portion

is placed in the chamber 62, this method is not a profitable one in view of the transferring method by the wafer transferring arm 56 and shortening of the wafer processing time (improvement in throughput), and so its execution is quite difficult.

The object of the present invention is attained in view of the aforesaid problems and consists in providing a heat treatment apparatus satisfying some conditions such as:

① that a high speed heating and a high speed cooling of the wafer can be performed within the specified high purity gas atmosphere (high purity N_2 gas atmosphere, for example);

② that after the entire inner part of the container is once evacuated by an evacuating device as means for making high purity gas atmosphere, the specified atmosphere can be made within a short period of time to feed the specified gas and replace it;

③ that although the wafer is processed one by one, a small load lock chamber is provided at a place where the wafer is loaded into or unloaded out of the container, this load lock chamber is evacuated, thereafter gas replacement is performed to keep the inner atmosphere and to enable both loading and unloading of the wafer to be performed; and

④ that arrangement of lamps at the upper surface and the lower surface of the chamber enables the wafer to be rotated by a wafer rotating mechanism from below the wafer and a wafer temperature measurement to be performed, so that improvement of temperature distribution of the wafer and its temperature control can easily be performed.

[Means for Solving the Problems]

In order to overcome the aforesaid problems and accomplish the aforesaid objects, the present invention provides a heat treatment apparatus for a semiconductor substrate in which a chamber is constituted by a load lock chamber 4 having an opening/closing door 4a opened when a wafer 11 is loaded/unloaded, a heat treatment chamber 12 for subjecting the wafer 11 to a heat treatment, and a wafer transferring chamber 3 in communication with both chambers 4, 12; a gate valve 7 for opening or closing a wafer loading/unloading port for both chambers 3, 4 is provided between the load lock chamber 4 and the wafer transferring chamber 3; a wafer holder 28 for moving the wafer 11 between the chambers 3, 4 is provided on the gate valve 7; the gate valve 7 is provided with the wafer holder 28 for transferring the wafer 11 between both chambers 3, 4, a gate valve 9 for opening or closing the wafer loading/unloading port for the chambers 3, 12 is provided between the wafer transferring chamber 3 and the heat

treatment chamber 12; a wafer holder 10 for moving the wafer 11 between the chambers 3, 12 and rotating the wafer 11 is provided on the gate valve 9; a wafer transferring mechanism 5 for loading which transfers the wafer 11 received from the wafer holder 28 and delivering the same to the wafer holder 10 and a wafer transferring mechanism 6 for unloading which performs an operation opposite to that of the wafer transferring mechanism 5 are provided in the wafer transferring chamber 3; a wafer cooling portion 8 is provided for cooling the wafer 11 being transferred by the wafer transferring mechanism 6; an exhausting device 18 and a gas supplying portion 17 are connected to the load lock chamber 4, the wafer transferring chamber 3, and the heat treatment chamber 12; and an upper surface heating source 13a for the wafer 11 and a side surface heating source 13b for the wafer 11 are provided on the upper part and the side part of the heat treatment chamber 12, respectively.

[Operation]

The opening/closing door 4a is opened, the gate valve 7 is closed, the wafer holder 28 is moved to the load lock chamber 4, and the wafer 11 loaded into the chamber 4 is mounted on the wafer holder 28. After this operation, the opening/closing door 4a and the gate valve 9 are closed, the load lock chamber 4, the wafer transferring chamber 3, and the heat treatment chamber 12 are evacuated by the

exhausting device 18, and then specified high purity gas is fed by the gas supplying portion 17 to replace the atmosphere in the chambers 4, 3 and 12 with the specified high purity gas atmosphere.

Under this state, the gate valve 7 is opened, the wafer holder 28 is moved to the wafer transferring chamber 3, the wafer 11 on the wafer holder 28 is transferred to the loading wafer transferring mechanism 5, and the wafer 11 is transferred into the wafer transferring chamber 3 by the transferring mechanism 5. This transferring mechanism 5 is stopped just before the heat treatment chamber 12, the gate valve 9 is opened, the wafer holder 10 is moved to the wafer transferring chamber 3, the loading transferring mechanism 5 is moved to the lower position of the heat treatment chamber 12, the wafer holder 10 is moved toward the heat treatment chamber 12, and the wafer 11 is transferred by the transferring mechanism 5 onto the wafer holder 10.

After this operation, the loading transferring mechanism 5 is returned from the lower position of the heat treatment chamber 12 to the side position, the wafer holder 10 is moved to the heat treatment chamber 12, the wafer 11 is loaded into the heat treatment chamber 12, and at the same time the gate 9 is closed. Under this state, the specified high purity gas is supplied to the heat treatment

chamber 12 by the gas supplying portion 17 and in turn, the chamber is evacuated by the exhausting device 18, the wafer holder 10 is rotated, the wafer 11 is uniformly heated by the upper surface heating source 13a and the side surface heating source 13b with the wafer being rotated, to subject the wafer to a heat treatment.

After this operation, the gate valve 9 is opened, the wafer holder 10 is moved to the wafer transferring chamber 3, and the wafer 11 is transferred from the heat treatment chamber 12 to the wafer transferring portion 3. Then, then unloading transferring mechanism 6 is moved to the lower position of the heat treatment chamber 12, the wafer 11 is transferred to the unloading transferring mechanism 6 during operation opposite to the foregoing, and is transferred to the wafer transferring portion 3.

During the transferring operation, the transferring mechanism 6 is once stopped at the position of the cooling portion 8 and after the wafer 11 is cooled with the cooling portion 8, the wafer is transferred by the unloading transferring mechanism 6 to the lower position of the load lock chamber 4. Then, the wafer 11 is loaded into the load lock chamber 4 during the operation opposite to the aforesaid operation and at the same time the gate valve 7 is closed, and the opening/closing door 4a is opened to unload the wafer 11.

[Examples]

Referring now to the drawings, some preferred embodiments of the present invention will be described as follows.

Fig. 1 is an illustrative view for showing a summary of a first preferred embodiment of the apparatus of the present invention; Fig. 2 is an illustrative perspective view for showing both constitution and operation of a wafer transferring mechanism for transferring a wafer between a wafer storing cassette and a load lock chamber in the present invention; Figs. 3(a) to (d) are illustrative sectional views for showing both constitution and operation around a gate valve between a load lock chamber and a wafer transferring chamber in the present invention; Figs. 4(a) to (c) are illustrative sectional views for showing an operation of a loading transferring mechanism of the wafer transferring chamber in the present invention; Fig. 5 is a perspective view for showing a constitution of a loading and unloading transferring mechanism of the wafer transferring chamber in the present invention; Figs. 6(a) to (f) are illustrative sectional views for showing both constitution and operation around the gate valve between the wafer transferring chamber and the heat treatment chamber in the present invention; Fig. 7 is similarly a simplified sectional view for showing a detailed

constitution around the gate valve; and Figs. 8(a), (b) are illustrative sectional views for showing both constitution and operation of a wafer cooling portion of the wafer transferring chamber in the present invention.

In Fig. 1, reference numeral 1 denotes a wafer storing cassette for storing a total number of 25 pieces of not-yet processed wafers and processed wafers in usual. One or a plurality of the cassettes 1 can be provided and operated. Reference numeral 2 denotes a wafer transferring mechanism for unloading a wafer 11 one by one from the cassette 1, loading the wafer into a load lock chamber 4 or performing an operation opposite to the foregoing. This wafer transferring mechanism 2 is, as shown in Fig. 2, for example, comprised of a first arm 26 supporting a shaft 26a at the supporting portion in a case 25 in such a way that it can be moved in a vertical direction and rotated; a second arm 27 provided on the first arm 26 in such a way that it can be moved forward or rearward and having a vacuum attraction portion (hole) 27a at the upper surface of thin-walled portion at the extremity end; a rotating mechanism and an ascending/descending mechanism (both of them not shown) for the first arm 26; and an exhausting device for the forward or rearward moving mechanism for the second arm 27 and the vacuum attraction portion (both of them not shown).

Reference numeral 4 denotes a load lock chamber having an opening/closing door 4a opened when the wafer 11 is loaded/unloaded; reference numeral 12 denotes a heat treatment chamber for subjecting the wafer 11 to a heat treatment; and reference numeral 3 denotes a wafer transferring chamber for communicating the lower portions of both chambers 4, 12. These chambers may constitute a chamber (air-sealed container). The heat treatment chamber 12 is made of transparent quartz, wherein its structure is constituted such that its shape is cylindrical to evacuate its inside portion and its ceiling part forms a spherical shape, and even if an external pressure is applied to it, it is not damaged.

Reference numeral 7 denotes a gate valve (refer to Fig. 3) provided between the load lock chamber 4 and the wafer transferring chamber 3 so as to perform opening/closing of the wafer loading/unloading port between both chambers 4 and 3. A valve shaft 7a of the gate valve 7 passes through the lower chamber wall of the wafer-transferring chamber 3 and is supported by a bearing 61 in such a way that it can be moved up and down. Reference numeral 28 denotes a wafer holder having a shaft 28a inserted into the through-pass hole of the valve shaft 7a of the gate valve 7 so as to move the wafer 11 between both chambers 4, 3. The valve shaft 7a of the gate valve 7 and

the shaft 28a of the wafer holder 28 are connected to the ascending/descending mechanism (not shown). Reference numeral 29a denotes a gas feeding pipe connected to the opening/closing door 4a; and reference numeral 15a denotes a gas feeding valve for use in feeding gas into the load lock chamber 4. Reference numeral 30 denotes an exhausting passage passed through the shaft 28a of the wafer holder 28 and opened at the upper side of the shaft 28a; reference numeral 31a denotes an exhausting pipe connected to the exhausting passage 30; and reference numeral 16a denotes an exhausting valve for use in exhausting the load lock chamber 4.

Reference numeral 5 denotes a wafer transferring mechanism for loading provided in the wafer transferring chamber 3 so as to transfer the wafer 11 received from the wafer holder 28 from the lower position of the load lock chamber 4 down to the lower position of the heat treatment chamber 12; reference numeral 6 denotes a wafer transferring mechanism for unloading provided just below the loading wafer transferring mechanism 5 so as to transfer the wafer 11 received from the wafer holder 10 from the lower position of the heat treatment chamber 12 to the lower position of the load lock chamber 4.

These transferring mechanisms 5, 6 are, as shown in Fig. 5, for example, comprised of a moving member 33 moved

along a guide shaft 32 through moving means (not shown) such as a screw feeder and a wire drive; and a fork arm 34 of which an arm base is fixed to the moving member 33 and for mounting the wafer 11 thereon.

Reference numeral 29b denotes a gas-feeding pipe communicated with the wafer-transferring chamber 3; and reference numeral 15b denotes a gas-feeding valve for feeding gas into the wafer-transferring chamber 3. Reference numeral 31b denotes an exhausting pipe communicated with the wafer-transferring chamber 3; and reference numeral 16b denotes an exhausting valve for exhausting the chamber 3.

Each of reference numerals 13a, 13b denotes many rod-like halogen lamps constituting an upper surface heating source and a side surface heating source provided at the upper part and the side part of the heat treatment chamber 12. The upper surface heating source has many rod-like halogen lamps 13a crossed to each other. The side surface heating source has many rod-like halogen lamps 13b provided at four sides in forward, rearward, rightward and leftward directions. Reference numeral 35 denotes a reflection plate coated with gold plating or the like at its surface for performing an efficient reflection of light of the lamps 13a, 13b; reference numeral 36 denotes a water passage provided for cooling the reflection plate 35; and

reference numeral 14 denotes a frame for supporting the lamps 13a, 13b. The heat treatment chamber 12 and the halogen lamps 13a, 13b may also perform cooling by forced air cooling (not shown).

Reference numeral 24 denotes a gas guide cylinder provided along the inner surface of the sidewall of the heat treatment chamber 12; reference numeral 29c denotes a gas-feeding pipe for communicating with the heat treatment chamber 12; reference numeral 37 denotes many gas injection holes provided at the base 23 of the heat treatment chamber 12 in its circumferential direction; and reference numeral 15c denotes a gas feeding valve for feeding gas between the side wall of the heat treatment chamber 12 and the gas guide cylinder 24 through a gas feeding pipe 29c, the gas feeding valve 15c and many gas injection holes 37. Reference numeral 31c denotes an exhausting pipe communicated with the heat treatment chamber 12; reference numeral 16c denotes an exhausting valve for exhausting the chamber 12.

Reference numeral 9 denotes a gate valve provided between the wafer-transferring chamber 3 and the heat treatment chamber 12 so as to open or close the wafer loading/unloading port between both chambers 3, 12. Reference numeral 38 denotes a water passage for cooling the gate valve. A reflection layer such as a gold plating

for performing an efficient reflection of light of the halogen lamps 13a, 13b is applied to the upper surface of the gate valve 9. Reference numeral 39 denotes a quartz plate on the reflection layer.

A valve shaft 9a of the gate valve 9 passes through the wall of the lower chamber of the wafer transferring chamber 3, is supported by a bearing 40 in such a way that it can be moved up and down and air-tightly kept by an air-tight seal 41. Reference numeral 42 denotes an ascending/descending device connected to the valve shaft 9a of the gate valve 9, for example, an ascending/descending cylinder.

Reference numeral 10 denotes a wafer holder for use in moving the wafer 11 between the wafer transferring chamber 3 and the heat treatment chamber 12 and for rotating the wafer 11. A shaft 10a of the wafer holder 10 passes through the valve shaft 9a of the gate valve 9, is supported by a bearing 43 in such a way that it can be moved up and down and is sealingly kept by an air-tight seal 44. Reference numeral 45 denotes an ascending/descending device connected to the shaft 10a of the wafer holder 10, for example, the ascending/descending cylinder; reference numeral 46 similarly denotes a rotary driving device connected to the shaft 10a, and this is comprised of a rotation transmittance mechanism 46a of gear

and a rotary motor 46b, for example.

Reference numeral 21 denotes a radiation temperature measuring unit provided in slant lower side of the base 23 of the heat treatment chamber 12 so as to measure a temperature of the wafer 11 mounted on the wafer holder 10. Reference numeral 22 denotes a temperature control device for use in controlling an electrical amount applied of the lamps 13a, 13b in response to the temperature measured by the temperature-measuring unit 21.

Reference numeral 17 denotes a gas-supplying portion communicated with the gas feeding pipe 29a of the load lock chamber 4, the gas feeding pipe 29b of the wafer transferring chamber 3 and the gas feeding pipe 29c of the heat treatment chamber 12. Reference numeral 18 denotes a gas-exhausting device communicated with the gas exhausting pipe 31a of the load lock chamber 4, the gas exhausting pipe 31b of the wafer transferring chamber 3 and the gas exhausting pipe 31c of the heat treatment chamber 12. Reference numeral 19 denotes a pressure control device for keeping pressures of the gas-supplying portion 17 and of the gas-exhausting device 18 constant. Reference numeral 20 denotes a wafer transferring control device for the wafer transferring mechanisms 2, 5, 6.

Reference numeral 8 denotes a wafer cooling portion installed in the wafer transferring chamber 3 for use in

cooling the wafer 11 during its transferring operation performed by the unloading wafer transferring mechanism 6. As shown in Fig. 8, for example, the wafer-cooling portion 8 is constructed such that a shaft 47a of a wafer cooling disk 47 is passed through the lower chamber wall of the wafer transferring chamber 3 so that the wafer-cooling portion is supported by a bearing 48 in such a way that it can be moved up and down while it is air-tightly held by an air-tight seal 49. The shaft 47a of the cooling disk 47 is provided with a water passage 50 for cooling the disk 47 so that a cooling water pipe 55 is communicated with the water passage 50. And then the ascending/descending device, for example, an ascending/descending cylinder 59 is connected to the shaft 47a of the cooling disk 47. Reference numeral 60 denotes a quartz plate provided at the upper surface of the cooling disk 47 so as to prevent the wafer from being directly contacted with the metallic cooling disk 47.

In the present invention, since the load lock chamber 4, the wafer transferring chamber 3 and the heat treatment chamber 12 are provided in series, the wafer transferring mechanisms 5, 6 of the wafer transferring chamber 3 are constituted such that the fork arm 34 is reciprocated in linear manner. It is also applicable that the wafer transferring chamber 3 and the load lock chamber 4 are provided on the same arcuate line around the heat

treatment chamber 12 and in this case, the wafer transferring mechanisms 5, 6 are constituted such that the fork arm 34 is rotatably reciprocated around the center of arc.

All the operations of the preferred embodiment of the present invention are operated automatically such that the not-yet-processed wafer 11 is unloaded from the wafer-storing cassette 1, this unloaded not-yet-processed wafer 11 is transferred into the heat treatment chamber 12 through the load lock chamber 4 and the wafer transferring chamber 3, and subjected to the heat treatment, the processed wafer 11 is unloaded in an opposite step and stored again in the wafer storing cassette 1, and its action will be described as follows.

In a case where the upper-most stage wafer 11 placed in the wafer-storing cassette 1 is unloaded, at first, the first arm 26 is lifted up to such a position as one (indicated by an imaginary line in Fig. 1) where the extremity end vacuum attraction portion 27a of the second arm 27 can be inserted into a clearance between the upper-most wafer in the cassette 1 and the wafer just below the upper-most wafer. At this time, the second arm 27 is kept at its retracted state where it is pulled into the most-rear end position of the first arm 26. In concurrent with this ascending or subsequent to this operation, the first

arm 26 is rotated up to a position θ_1 (refer to Fig. 2) where it is coincided with the center line of the cassette 1. Then, the second arm 27 is advanced forward and stops when the wafer 11 can be attracted at the vacuum attraction portion 27a at its extremity end. The first arm 26 is slightly lifted up to cause the extremity end vacuum attraction portion 27a to be oppositely contacted with the upper-most stage wafer 11 in the cassette 1 and then the wafer 11 is attracted to the vacuum attraction portion 27a. At the time of attracting the wafer, its lifting is stopped, the second arm 27 is retracted and upon completion of its retraction, the first arm 26 is rotated up to a position θ_2 where the wafer can be loaded into the load lock chamber 4.

In a case where the wafer is loaded into the load lock chamber 4, as shown in Fig. 3(a), the opening/closing door 4a is lifted up and opened, the gate valve 7 and the wafer holder 28 are lifted up to keep the gate valve 7 in its closed state. Under this state, the atmosphere in the wafer-transferring chamber 3 is completely shielded against the surrounding atmosphere, resulting in that the wafer loading operation for the load lock chamber 4 can be performed.

Then, after the second arm 27 is advanced forward as shown in Fig. 2 and stopped at the most-forward position, the first arm 26 is descended again. When the wafer 11 is

contacted with the upper surface of the wafer holder 28, the first arm 26 is stopped descending and the attracted state of the wafer is released. After this operation, the first arm 26 is slightly lowered and it is returned back to its original position through retraction of the second arm 27, and ascending operation of the first arm 26.

This operation results in that the wafer 11 is transferred from the cassette 1 to the load lock chamber 4. In a case where the wafer 11 is stored in the cassette 1, it is satisfactory to perform operation opposite to the aforesaid operation. Since unloading of the wafer from the cassette 1 and storing of the wafer into the cassette 1 are alternatively repeated in sequence, the wafer can be processed continuously. In the examples shown in Figs. 1 and 2, they show the case that one cassette 1 is stored. However, if a plurality of (the maximum number of 5 in this example) wafers are installed in a radial manner around the position of the wafer transferring mechanism 2, it is possible to perform a continuous work even after one cassette is finished for operation.

Fig. 3(b) illustrates a state in which the wafer 11 is loaded into the load lock chamber 4 by the wafer transferring mechanism 2 as described above, and the wafer is placed on the wafer holder 28. Under this state, the opening/closing door 4a is lowered as shown in Fig. 3(c)

and closed. After this operation, the exhausting valves 16a to 16c (refer to Fig. 1) are opened and the exhausting device 18 is operated to evacuate the load lock chamber 4, the wafer transferring chamber 3 and the heat treatment chamber 12. At this time, the gate valve 9 is closed. Atmosphere in each of the chambers 4, 3, 12 becomes a predetermined vacuum state by the vacuum evacuation. After this operation, the gas feeding valves 15a to 15c are opened and the specified high purity gas is fed into each of the chambers 4, 3, 12 through the gas supplying portion 17. Thus the atmosphere in the chamber is replaced with the specified high purity gas atmosphere rapidly and positively. The wafer 11 on the wafer holder 28 is loaded into the wafer transferring chamber 3 in concurrent with the descending of the gate valve 7 and the wafer holder 28 and opening of the gate valve 7 as shown in Fig. 3(d) under a state in which the load lock chamber 4 is replaced with high purity gas.

The fork arm 34 (refer to Fig. 5) of the loading wafer transferring mechanism 5 is moved in a horizontal direction under this loaded state until it is positioned between the wafer 11 and the gate valve 7 as shown in Fig. 4(a). Then the gate valve 7 and the wafer holder 28 are lowered as shown in Fig. 4(b), and the wafer 11 on the wafer holder 28 is transferred onto the loading fork arm 34.

After this operation, the loading fork arm 34 is moved in a horizontal direction toward the heat treatment chamber 12 as shown in Fig. 4(c) and it is stopped just below and just before the heat treatment chamber 12 as shown in Fig. 6(a).

In a case where the wafer 11 is loaded into the heat treatment chamber 12 from this state, the gate valve 9 and the wafer holder 10 are lowered as shown in Fig. 6(a) to enable the wafer to be loaded by the fork arm 34 of the loading wafer transferring mechanism 5. Then, the fork arm 34 of the loading wafer transferring mechanism 5 is moved to the lower position of the heat treatment chamber 12. After this operation, as shown in Fig. 6(b), the wafer holder 10 is lifted up and the wafer 11 on the fork arm 34 is transferred onto the wafer holder 10. After this operation, the fork arm 34 of the loading wafer transferring mechanism 5 is returned back to the position shown in Fig. 6(a). At this time, the fork arm 34 can be passed and returned back to the original position without being struck against the wafer holder 10 at a space part of the forks.

After this operation as shown in Fig. 6(c), the gate valve 9 and the wafer holder 10 are lifted, the wafer 11 is loaded into the heat treatment chamber 12 and the gate valve 9 is closed. The heat treatment for the wafer is performed under this state (refer to Fig. 7). That is,

under the state shown in Fig. 6(c) and Fig. 7, the atmosphere in the heat treatment chamber 12 has become the high purity gas atmosphere already specified, so that the gas feeding valve 15c is opened and the exhausting valve 16c is opened. The specified high purity gas is injected out by the gas supplying portion 17 from the gas injection hole 37 through the gas feeding pipe 29c. The gas passes between a chamber wall of the heat treatment chamber 12 and the gas guide cylinder 24, passes in the heat treatment chamber 12 and is discharged out of the exhausting pipe 31c.

The wafer 11 on the wafer holder 10 is heated by the lamp 13a of the upper surface heating source and the lamp 13b of the side surface heating source while such a gas flowing state is being kept and the wafer holder 10 is being rotated. Temperature of the wafer 11 is measured by a radiation temperature-measuring unit 21. An amount of aeration for the lamps 13a, 13b is controlled by the temperature control device 22 in response to the measured temperature and rotation of the wafer holder 10 is controlled. Thus a uniform heating can be performed against the entire surface of the wafer 11.

Upon completion of the heat treatment of the wafer, as shown in Fig. 6(d), the gate valve 9 and the wafer holder 10 are lowered, the gate valve 9 is opened and at the same time the wafer 11 is transferred from the heat

treatment chamber 12 to the wafer transferring chamber 3. After this operation, as shown in Fig. 6 (e), the fork arm 34 of the unloading wafer transferring mechanism 6 is moved to the lower position of the heat treatment chamber 12. Then the wafer holder 10 is lowered and the wafer 11 is transferred onto the fork arm 34 of the unloading wafer transferring mechanism 6. After this operation, the fork arm 34 is returned back to its original position shown in Fig. 6(f).

In a case where the wafer 11 is transferred by the unloading transferring mechanism 6 from the state shown in Fig. 6(f) to the lower position of the load lock chamber 4, it is transferred in the operation step opposite to the wafer transferring operation performed by the loading transferring mechanism 5. When it comes to the position just above the wafer cooling portion 8 during its transferring operation, its transferring is once stopped as shown in Fig. 8(a). After this operation, as shown in Fig. 8(b), the cooling disk 47 of the wafer cooling portion 8 is lifted up and the wafer 11 is transferred onto the cooling disk 47. Upon transferring of the wafer 11, its lifting is stopped and cooling water is fed by a cooling water pipe 55 to cool the wafer 11. This cooling operation is required to prevent oxidation or the like by cooling the wafer 11 before the wafer heated by the heat treatment chamber 12 is

unloaded to the surrounding atmosphere.

Upon completion of the cooling operation, as shown in Fig. 8(a), the cooling disk 47 is lowered so that the wafer 11 is transferred again onto the fork arm 34 of the unloading transferring mechanism 6 and it is transferred to the lower position of the load lock chamber 4. Wafer transferring operation from the wafer-transferring chamber 3 to the load lock chamber 4 and from the load lock chamber 4 to the wafer-storing cassette 1 are sufficiently performed in the operation step opposite to the aforesaid operation step.

[Effects of the Invention]

As apparent from the foregoing description, in accordance with the present invention, the present invention provides a heat treatment apparatus for a semiconductor substrate in which a chamber is constituted by a load lock chamber 4 having an opening/closing door 4a opened when a wafer 11 is loaded/unloaded, a heat treatment chamber 12 for subjecting the wafer 11 to a heat treatment, and a wafer transferring chamber 3 in communication with both chambers 4, 12; a gate valve 7 for opening or closing a wafer loading/unloading port for both chambers 3, 4 is provided between the load lock chamber 4 and the wafer transferring chamber 3; a wafer holder 28 for moving the wafer 11 between the chambers 3, 4 is provided on the gate

valve 7; the gate valve 7 is provided with the wafer holder 28 for transferring the wafer 11 between both chambers 3, 4, a gate valve 9 for opening or closing the wafer loading/unloading port for the chambers 3, 12 is provided between the wafer transferring chamber 3 and the heat treatment chamber 12; a wafer holder 10 for moving the wafer 11 between the chambers 3, 12 and rotating the wafer 11 is provided on the gate valve 9; a wafer transferring mechanism 5 for loading which transfers the wafer 11 received from the wafer holder 28 and delivering the same to the wafer holder 10 and a wafer transferring mechanism 6 for unloading which performs an operation opposite to that of the wafer transferring mechanism 5 are provided in the wafer transferring chamber 3; a wafer cooling portion 8 is provided for cooling the wafer 11 being transferred by the wafer transferring mechanism 6; an exhausting device 18 and a gas supplying portion 17 are connected to the load lock chamber 4, the wafer transferring chamber 3, and the heat treatment chamber 12; and an upper surface heating source 13a for the wafer 11 and a side surface heating source 13b for the wafer 11 are provided on the upper part and the side part of the heat treatment chamber 12, respectively. Thus the opening/closing door 4a and the gate valves 7, 9 are closed after the wafer 11 is loaded from the surrounding atmosphere into the load lock chamber 4, the

load lock chamber 4, the wafer transferring chamber 3, and the heat treatment chamber 12 are replaced with the specified high purity gas atmosphere by the exhausting device 18 and the gas supplying portion 17, the wafer 11 is supplied to the heat treatment chamber 12 and is subjected to a heat treatment through opening of the gate valves 7, 9, operation of the wafer holders 28, 10 and operation of the loading and unloading transferring mechanisms 5, 6 while the gas atmosphere is being kept, and the wafer 11 after its heat treatment can be returned back to the load lock chamber 4.

Within the heat treatment chamber 12, the wafer 11 can be heated by the upper surface heating source 13a and the side surface heating source 13b while the wafer holder 10 is rotated in the high purity gas atmosphere specified and the wafer 11 is rotated. Therefore an entire surface of the wafer 11 can be uniformly heated and subjected to a heat treatment.

Since the radiation temperature measuring unit 21 can be installed at the lower side part of the heat treatment chamber 12, a temperature of the wafer 11 can be measured by the measuring unit 21, an amount of applied electricity of the upper surface heating source 13a and the side surface heating source 13b is controlled by the temperature control device 22 in response to the measured

temperature to cause the temperature distribution in the wafer surface to be further uniform, whereby the heat treatment of the wafer can be performed more satisfactorily.

In addition, the wafer 11 after its heat treatment can be cooled by the wafer cooling unit 8 provided in the wafer transferring chamber 3 during the transferring operation by the unloading wafer transferring mechanism 6 and further the wafer 11 after cooling operation can be unloaded into the surrounding atmosphere from the load lock chamber 4. Therefore oxidation or the like can be prevented.

Further, it has also an effect that the entire device can be made compact in size.

4. Brief Description of the Drawings

Fig. 1 is an illustrative view for showing an outline of an embodiment of the apparatus of the present invention;

Fig. 2 is an illustrative perspective view for showing the constitution and operation of a wafer transferring mechanism for transferring a wafer between a wafer storing cassette and a load lock chamber in the present invention;

Figs. 3(a) to (d) are illustrative sectional views for showing the constitution and operation around a gate

valve between a load lock chamber and a wafer transferring chamber in the present invention;

Figs. 4(a) to (c) are illustrative sectional views for showing an operation of a loading transferring mechanism of the wafer transferring chamber in the present invention;

Fig. 5 is a perspective view for showing a constitution of loading and unloading transferring mechanisms of the wafer transferring chamber in the present invention;

Figs. 6(a) to (f) are illustrative sectional views for showing the constitution and operation around a gate valve between the wafer transferring chamber and the heat treatment chamber in the present invention;

Fig. 7 is similarly a simplified sectional view for showing a detailed constitution of Fig. 6;

Figs. 8(a), (b) are illustrative sectional views for showing the constitution and operation of the wafer cooling portion of the wafer transferring chamber in the present invention; and

Fig. 9 is a perspective view for showing a schematic constitution of a heat treatment device using a rod-like halogen lamp widely used in the prior art.

1: wafer storing cassette   2: wafer transferring mechanism
3: wafer transferring chamber   4: load lock chamber   4a:

opening/closing door 5: wafer transferring mechanism for loading 6: wafer transferring mechanism for unloading 7: gate valve 7a: valve shaft 8: wafer cooling portion 9: gate valve 9a: valve shaft 10: wafer holder 10a: shaft 11: wafer 12: heat treatment chamber 13a: upper surface heating source (rod-like halogen lamp) 13b: side surface heating source (rod-like halogen lamp) 13c: lower surface heating source (rod-like halogen lamp) 15a to 15c: gas feeding valve 16a to 16c: exhausting valve 17: gas supplying portion 18: exhausting device 20: wafer transferring control device

21: radiation temperature measuring unit 22: temperature control device 26: first arm 26a: shaft 27: second arm 27a: vacuum attraction portion 28: wafer holder 28a: shaft 29a to 29c: gas feeding pipe 30: exhausting passage 31a to 31c: exhausting pipe 32: guide shaft 33: moving member 34: fork arm 42, 45, 59: ascending/descending device (ascending/descending cylinder) 46: rotation driving device 47: wafer cooling disk 47a: shaft 58: wafer loading/unloading port